

Homework 20 (Use of L-BFGS-B for constrained minimization)

L-BFGS-B is an algorithm for solving large scale optimization problems subject to simple bounds .

It is based on the gradient projection method and uses a limited memory BFGS matrix to approximate the Hessian of the objective function.

The problem is

$\min f(x)$

subject to $l \leq x \leq u$

where l and u are the lower and upper bounds on the variables.

1. Run the executable `x1.lbfgs` with the example provided by Ciyou Zhu and Jorge Nocedal.
2. Original code available at:

<http://www-fp.mcs.anl.gov/otc/Tools/LBFGS-B/>

The `tar.gz` code is available on blackboard along with the papers

3. Describe in some detail the method based on which the code works and the constrained and unconstrained minimization methods used.
4. Describe the algorithmic procedure employed.
5. Compare results using `driver1.f` with those using `driver2.f` with its executable `x.lbfgsb2`

Typical output:

Solving sample problem.

($f = 0.0$ at the optimal solution.)

RUNNING THE L-BFGS-B CODE

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Machine precision = 1.084E-19

N = 25 M = 5

At X0 0 variables are exactly at the bounds

At iterate 0 f= 3.46000E+03 |proj g|= 1.03000E+02

At iterate 1 f= 2.39769E+03 |proj g|= 6.50700E+01

At iterate 2 f= 1.43806E+02 |proj g|= 3.64039E+01

At iterate 3 f= 7.28161E+01 |proj g|= 2.29042E+01

At iterate 4 f= 1.60308E+01 |proj g|= 6.95409E+00

At iterate 5 f= 5.18725E+00 |proj g|= 9.05481E+00

Bad direction in the line search;

refresh the lbfgs memory and restart the iteration.

At iterate 6 f= 2.87083E+00 |proj g|= 7.13636E+00

At iterate 7 f= 1.79199E+00 |proj g|= 2.20353E+00

At iterate 8 f= 9.66509E-02 |proj g|= 1.08444E+00

At iterate 9 f= 6.89435E-02 |proj g|= 1.86879E+00

At iterate 10 f= 1.03044E-02 |proj g|= 3.99596E-01

Bad direction in the line search;

refresh the lbfgs memory and restart the iteration.

At iterate 11 f= 6.72864E-03 |proj g|= 2.41447E-01

At iterate 12 f= 4.73618E-03 |proj g|= 1.10894E-01

At iterate 13 f= 2.99421E-03 |proj g|= 1.27485E-01

At iterate 14 f= 6.85522E-04 |proj g|= 2.00284E-01

Bad direction in the line search;

refresh the lbfgs memory and restart the iteration.

At iterate 15 f= 3.24501E-04 |proj g|= 6.74779E-02

At iterate 16 f= 2.35628E-04 |proj g|= 3.87544E-02

At iterate 17 f= 9.81723E-05 |proj g|= 1.61094E-02

At iterate 18 f= 3.82676E-05 |proj g|= 1.75894E-02

At iterate 19 f= 1.27763E-05 |proj g|= 2.02902E-02

Bad direction in the line search;
refresh the lbfgs memory and restart the iteration.

At iterate 20 f= 3.04469E-06 |proj g|= 1.04260E-02

At iterate 21 f= 2.00330E-06 |proj g|= 2.38175E-03

At iterate 22 f= 1.60261E-06 |proj g|= 1.86650E-03

Bad direction in the line search;
refresh the lbfgs memory and restart the iteration.

At iterate 23 f= 1.40305E-06 |proj g|= 3.26593E-03

At iterate 24 f= 1.05369E-06 |proj g|= 2.08653E-03

At iterate 25 f= 1.26016E-07 |proj g|= 2.04081E-03

At iterate 26 f= 4.72616E-08 |proj g|= 7.48498E-04

At iterate 27 f= 2.09876E-08 |proj g|= 4.48829E-04

At iterate 28 f= 3.77637E-09 |proj g|= 1.63165E-04

At iterate 29 f= 6.83331E-10 |proj g|= 8.36442E-05

Bad direction in the line search;
refresh the lbfgs memory and restart the iteration.

At iterate 30 f= 3.51318E-10 |proj g|= 8.18690E-05

At iterate 31 f= 2.15502E-10 |proj g|= 3.41499E-05

At iterate 32 f= 1.18762E-10 |proj g|= 3.30345E-05

At iterate 33 f= 2.73518E-11 |proj g|= 3.26781E-05

At iterate 34 f= 1.39133E-11 |proj g|= 2.47513E-05

At iterate 35 f= 3.56995E-12 |proj g|= 6.10832E-06

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Tit = total number of iterations

Tnf = total number of function evaluations

Tnint = total number of segments explored during Cauchy searches

Skip = number of BFGS updates skipped

Nact = number of active bounds at final generalized Cauchy point

Projg = norm of the final projected gradient

F = final function value

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N	Tit	Tnf	Tnint	Skip	Nact	Projg	F
25	35	47	105	0	0	6.108E-06	3.570E-12

F = 3.56995087E-12

CONVERGENCE: NORM OF PROJECTED GRADIENT <= PGTOL

Cauchy time 0.000E+00 seconds.

Subspace minimization time 0.000E+00 seconds.

Line search time 0.000E+00 seconds.

Total User time 0.000E+00 seconds.